

WHAT IS CLAIMED IS:

1. A ferro-electric memory device comprising:  
a semiconductor substrate;  
a first transistor formed on the semiconductor  
5 substrate; and  
a first ferro-electric capacitor electrically  
connected to the first transistor and formed of a  
first capacitor material layer having a first lower  
electrode, a first ferro-electric film, and a first  
10 upper electrode, the first ferro-electric capacitor  
being thicker at its central portion than at its ends.
2. The ferro-electric memory device according to  
claim 1, wherein the first ferro-electric capacitor has  
a bowl shape with a curved top surface.
- 15 3. The ferro-electric memory device according to  
claim 1, further comprising a first insulating film  
formed on the first transistor and the semiconductor  
substrate and having a groove with curved sides, and  
wherein the first ferro-electric capacitor is  
20 provided in the groove.
4. The ferro-electric memory device according to  
claim 1, the first lower electrode is formed of a  
material having an oxygen diffusion prevention effect.
5. The ferro-electric memory device according to  
25 claim 1, further comprising:  
a second transistor formed on the semiconductor  
substrate; and

a second ferro-electric capacitor electrically connected to the second transistor and formed of a second capacitor material layer having a second lower electrode, a second ferro-electric film, and a second upper electrode, the second ferro-electric capacitor being thicker at its central portion than at its ends, and

wherein a first cell in which the first upper electrode and the first lower electrode are electrically connected in parallel with first sources/drains of the first transistor is electrically connected in series with a second cell in which the second upper electrode and the second lower electrode are electrically connected in parallel with second sources/drains of the second transistor.

6. The ferro-electric memory device according to claim 5, further comprising:

a first contact provided adjacent to the first upper electrode to electrically connect the first upper electrode and one of the first sources/drains; and

a second contact provided adjacent to the second upper electrode to electrically connect the second upper electrode and one of the second sources/drains.

7. The ferro-electric memory device according to claim 6, wherein the first upper electrode covers the first lower electrode, and the second upper electrode covers the second lower electrode.

8. The ferro-electric memory device according to claim 1, wherein the first ferro-electric capacitor is conical.

9. A method of manufacturing a ferro-electric memory device, the method comprising:

forming a first transistor on a semiconductor substrate;

forming a first insulating film on the first transistor and semiconductor substrate;

forming a mask layer on the first insulating film;

forming a first opening in the mask layer;

using the mask layer to remove the first insulating film and forming a first groove in the first insulating film;

using sputtering to deposit a first lower electrode, a first ferro-electric film, and a first upper electrode on the mask layer and in the first groove and forming a first ferro-electric capacitor in the first groove in a self-aligned manner; and

removing the first lower electrode, first ferro-electric film, and first upper electrode from the mask layer.

10. The method of manufacturing a ferro-electric memory device according to claim 9, wherein the first groove is formed to be wider than the first opening by removing the first insulating film by anisotropic etching and then by isotropic etching.

11. The method of manufacturing a ferro-electric memory device according to claim 9, wherein sides of the first groove are curved.

12. The method of manufacturing a ferro-electric memory device according to claim 9, wherein the first ferro-electric capacitor is thicker at its central portion than at its ends.

13. The method of manufacturing a ferro-electric memory device according to claim 9, wherein the first ferro-electric capacitor has a bowl shape with a curved top surface.

14. The method of manufacturing a ferro-electric memory device according to claim 9, further comprising:

forming a second transistor on the semiconductor substrate when forming the first transistor;

forming a second opening in the mask layer when forming the first opening;

forming a second groove in the first insulating film when forming the first groove; and

forming a second ferro-electric capacitor having a second lower electrode, a second ferro-electric film, and a second upper electrode, in a second groove when forming the first ferro-electric capacitor, and

wherein a first cell in which the first upper electrode and the first lower electrode are electrically connected in parallel with first sources/drains of the first transistor is electrically connected in

series with a second cell in which the second upper electrode and the second lower electrode are electrically connected in parallel with second sources/drains of the second transistor.

5           15. The method of manufacturing a ferro-electric memory device according to claim 14, further comprising:

              depositing the first and second lower electrodes in the first and second grooves, respectively, by  
10           sputtering;

              increasing the width of the first and second grooves by isotropic etching; and

              depositing the first and second ferro-electric films and the first and second upper electrodes in the  
15           first and second grooves, respectively, by sputtering.

              16. The method of manufacturing a ferro-electric memory device according to claim 14, further comprising:

              forming, in a self-aligned manner, a first contact  
20           provided adjacent to the first upper electrode to electrically connect the first upper electrode and one of the first sources/drains; and

              forming, in a self-aligned manner, a second contact provided adjacent to the second upper electrode  
25           to electrically connect the second upper electrode and one of the second sources/drains.

              17. The method of manufacturing a ferro-electric

memory device according to claim 14, wherein the first upper electrode covers the first lower electrode, and the second upper electrode covers the second lower electrode.

- 5           18. The method of manufacturing a ferro-electric memory device according to claim 14, wherein the first ferro-electric capacitor is conical.